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**Integrating ergonomics knowledge into business-driven design projects: The shaping of resource constraints in engineering consultancy**

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**Abstract.**

**BACKGROUND:** The integration of ergonomics knowledge into engineering projects leads to both healthier and more efficient workplaces. There is a lack of knowledge about integrating ergonomic knowledge into the design practice in engineering consultancies.

**OBJECTIVES:** This study explores how organizational resources can pose constraints for the integration of ergonomics knowledge into engineering design projects in a business-driven setting, and how ergonomists cope with these resource constraints.

**PARTICIPANTS:** An exploratory case study in an engineering consultancy was conducted. A total of 27 participants were interviewed.

**METHODS:** Data were collected applying semi-structured interviews, observations, and documentary studies. Interviews were transcribed, coded, and categorized into themes.

**RESULTS:** From the analysis five overall themes emerged as major constituents of resource constraints: 1) maximizing project revenue, 2) payment for ergonomics services, 3) value of ergonomic services, 4) role of the client, and 5) coping strategies to overcome resource constraints.

**CONCLUSION:** We hypothesize that resource constraints were shaped due to sub-optimization of costs in design projects. The economical contribution of ergonomics measures was not evaluated in the entire life cycle of a designed workplace. Coping strategies included teaming up with engineering designers in the sales process or creating an alliance with ergonomists in the client organization.

**Keywords:** Engineering consultancy, engineering design, resources, organizational design and management

## 1. Introduction

Although the integration of ergonomic knowledge in engineering has been shown to lead to both healthier and effective designs of workplaces [1,2,3], little research has been conducted on integrating ergonomic knowledge into the design practice in engineering consultancies, a common setting for engineering design. In this paper, we report on a case study in an engineering consultancy firm, which during 2006-2007 acquired three different occupational health and safety (OHS) consultancies to broaden their line of consultancy services. Design tasks undertaken here are carried out in a client-consultant setting and can be characterized as business-driven: Engineering consultancies engage in design to provide a service for a client *and* to generate a profit in the consultancy. We found that the integration of ergonomic knowledge into this business-driven design context was constrained by an aspect of resources. The term 'resources' refers to the employee hours used and money needed to carry out a service for a client; for instance, provide engineering or ergonomic consultancy services in a design task. In this paper, we shed a light on what shapes these resource constraints in a setting where the entire revenue is based solely on consultancy services. We focus specifically on ergonomic knowledge in the form of ergonomic services provided by the engineering consultancy's own ergonomists, and identify how the ergonomists cope with resource constraints. We conclude by hypothesizing on how ergonomics can be integrated into engineering design tasks undertaken in business-driven design settings.

Previous studies show that resources can constitute a constraint for ergonomic initiatives. With regard to participatory ergonomics (PE), Eerd et al. [4] conducted a literature review that concluded that resources were one of the most frequent reported factors influencing success in PE initiatives. Studies of ergonomic interventions also identify resource allocation to be a barrier for the implementation of ergonomic activities [5,6]. Kirwan [5] found that even though management was willing to invest in ergonomic activities, it constantly demanded that benefits gained from ergonomic initiatives be accounted for, a pattern that had

been previously discussed by Perrow [7]. However, researchers have only given minor attention to the role of resources when involving ergonomists in design.

Bruseberg [8] accounts for the value of ergonomic contributions in design. She finds that ergonomic activities are often given low priority when budgets are made, and that this can be linked to the view that ergonomic activities are costly. Waterson and Kolose [9] report similar findings. An often-discussed challenge among ergonomists is to argue for the cost benefits of ergonomic initiatives [5,8,10,11,12,13,14,15]. These challenges are often linked to the intangible benefits of ergonomics [8,11,16,17] and the hidden nature of the costs of employees' ill health [18]. Studies of the Norwegian offshore industry also reveal that such issues as time, space and costs can constitute constraints for the implementation of ergonomic design criteria in design solutions [19,20]. Béguin [21] and Haslegrave and Holmes [22] also pointed to resources, in the form of time and money, as constraints in design processes. Little is known, however, about what shapes these resource constraints in engineering consultancy settings.

In the present study, we explore how resources are shaped as a constraint in a "natural" design context in an engineering consultancy, without the researcher being directly involved. The purpose of the paper is twofold: (1) to explore the shaping of the resource constraints, and (2) to gain knowledge about how ergonomists cope with the resource constraints. The paper begins by introducing the research setting and methods. Subsequently, the different constituents of the resource constraints are presented, followed by a discussion of the findings. This discussion concludes by hypothesizing about how the involvement of the ergonomic profession can be promoted in a business-driven design setting.

## **2. Setting**

Due to a political decision in Denmark, public funding for occupational health and safety (OHS) services was phased out during the period from 2005 to 2008. This created a new market situation, since OHS services now had to compete on the private market. During the same period, many of the larger engineering consultancies in Denmark established ergonomic/OHS

departments within their organizations. The setting for the present study is an engineering consultancy, which during the period from 2006 to 2007 acquired three different OHS consultancies. This consultancy delivered engineering services to a range of different business areas, such as hospitals, dairies, breweries, pharmaceutical producers, food producers and universities. The rationale for acquiring the OHS consultancies was based on a desire to have a greater palette of competencies with which to access the market, and to be able to offer OHS services to clients after design project were completed. The CEO at the time explained that her ambition was to be able to integrate ergonomic services into design projects in order to increase the quality of the projects. All along, however, the main strategy for the OHS departments was that they should be independently profitable, aside from the engineering design tasks, by selling more traditional ergonomic services. No resources were earmarked for integrating ergonomic services into the design process. At the time of the study, due to these acquisitions, the consultancy firm was in a phase of transition. No formal processes had been set up for how to integrate the ergonomic skills into the engineering design processes, and both ergonomists and engineering designers were inexperienced in working together on projects. Activities were developing aiming at integrating the newly acquired ergonomic skills in the engineering design processes, and this was happening from different actors and different locations in the organization. This study is therefore carried out at a 'formative' point in time as the ergonomists start working alongside engineers in the design projects.

### **3. Methodology**

According to Thomas [23], an explorative case study is appropriate when the objective is to generate in-depth understanding. Yin [24] operates with four different types of designs for case studies see Table 1.

Insert Table 1 about here

In this study, a single embedded case study was carried out in the engineering consultancy, where attention was directed toward both the overall case study (the engineering consultancy) and the three embedded design projects in the consultancy firm where ergonomists were involved in the design task. This type of study was chosen because the interest in the phenomenon being studied was two-sided: We wished to gain a better understanding of resource constraints at both the organizational level of the engineering consultancy firm *and* on the design project level.

The study was conducted in a ‘natural’ design context, without researchers being directly involved in the design process. The primary data source was interviews, which were supplemented by observation and document studies. The method can be characterized as a ‘natural experiment’, where the experimental conditions were outside the control of the researchers. We studied how actors in the engineering consultancy handled the integration of ergonomic knowledge into the engineering design projects after the engineering consultancy took over the OHS consultancies and physically placed the ergonomist at the same locations as the engineering designers.

### *3.1 Case selection*

Both the overall case unit and the embedded cases were chosen on the basis of “purposive sampling” [25], where the selection criteria were information-oriented, since we searched “typical” cases: For the overall case company, we wanted to find an engineering consultancy firm with in house ergonomic competencies. For the embedded case units, we looked for projects where ergonomic knowledge had been involved in the design process or were about to be integrated. The selected case units were 1) the design of a sterile processing plant, 2) a conceptual design plan for a seafood company, and 3) the design of a hospital. See Table 2 for case characteristics.

Insert Table 2 about here

### 3.2 Data collection

*Interviews* – A total of 23 persons were interviewed in the engineering consultancy firm: CEOs (N=2), ergonomists (N=10) and engineering design actors (engineers N=6, nurses N=2, other professions N=2). Furthermore, in the case of the sterile processing plant, two interviews were carried out in the client organization: two ergonomists, a health and safety representative and a manager were interviewed to gain insights on how they experienced the particular case project and whether or not the ergonomic input made it into the actual design of the sterile processing plant. In all three embedded cases, both engineering designers and ergonomists were interviewed to ensure a variety of perspectives. All interviews were semi-structured [26] and open-ended. The interview guides were modified during the course of the interviews as new insights arose and different actors were interviewed. The interviews were carried out face-to-face and varied in length from 30 to 120 minutes. They were audio-recorded and all essential parts were transcribed. There were three exceptions where interviewees did not wish to be audio-recorded, and in one incident where no audio-recorder was available. More informal ethnographic interviews [27] were also a part of the data material.

*Observations* – Data collection stretched over a time period of three years from 2009-2012. During this period, the first author spent approximately two working days per week in the engineering consultancy firm, the first two years in an engineering department and the last year in an ergonomic department. This allowed informal interactions. Field notes were made whenever anything related to the subject of interest was experienced.

### 3.3 Data analysis

The data analysis was based on an inductive approach [28]. Based on several close readings of the transcribed interviews and field notes, the first author systematically coded the data material in categories. The coding process was inspired by the “constant comparative method [29], where coding and analysis processes are combined to allow categories/theory to



emerge from data. In this process, all categories were labeled on the basis of interpretations of data material, and in accordance with Thomas [28], all contradictory point of views or findings were included in the categories. Through constantly comparing incidents and rearranging the different categories, new and more saturated categories emerged. Discussions and dialogues between all three authors supported the coding and analysis process, and memos were kept in a separate file to grasp different ideas and categories.

## **4. Results**

The coding activities resulted in the following five categories adding up to the overall category of “resource constraints”: “maximizing project revenue”, “payment for ergonomic services”, “the value of ergonomic services”, “the role of the client” and “coping and forming strategies to overcome resource constraints”. The categories are presented in the following sections.

### *4.1 Maximizing project revenue*

Maximizing the revenue from projects was a major barrier for the ergonomists’ involvement in the projects. This was one of the focus points in the consultancy’s performance measurement system. An identified condition was that the engineering designers had the role of being Project Managers (PM) and salespersons. In this role, they were in charge of the design projects, which included staffing, resource allocation and balancing budgets. Both engineering designers and ergonomists frequently reported that financial aspects governed whether or not ergonomists were involved in projects.

Engineering Designer (ED): “In projects where we are extremely pressed, we might consider whether to spend a day on an ergonomist or whether the financial aspects weighed more...”

Ergonomist: “We really want to be a part of projects, but even though a wish exists to include ergonomics, it is the last area that receives any resources. As a result, financial aspects often govern whether we are involved or not.”

Ergonomist: “We [the ergonomists] are looked upon as tax... and many [project managers] think: ‘This time I will not pay tax’.”

Once a project had been initiated, the engineering designers’ focus was to deliver the product agreed upon to the client, and at the same time minimize the costs in order to maximize the project revenue.

PM: “There is one total budget and this [allocating more money for ergonomics] means that there is less money for something else. ... It is the usual fight in all projects. If I was an ergonomist, I would argue differently and say that ergonomics is the most important aspect in the project, and that’s the way it should be...”

ED: “There is always a time discussion in the house [in the engineering consultancy firm]. I might say, ‘We have to make this tender, do you want to join?’ ‘Yes, I need 25 hours’. ... Who should pay for that? Then, the whole discussion starts and somebody will say: ‘That’s a burden on my project. Maybe we should just do it alone, because then I get a better factor [revenue of the project]’. These factor discussions are probably not promoting this [the integration of ergonomics in design projects].”

The ergonomists typically experienced a fight to gain resources and used rhetoric like: “The allocated hours were very limited”; “there are many small kings who do not want to give away hours”; and “they fought until blood was running in the streets”. Many of the ergonomists also experienced time pressure when involved in design tasks. The experienced time pressure was due to the limited amount of resources for ergonomic counseling (time to visit the workspace, talk to users etc.); short deadlines for the design tasks; and ergonomists being engaged in several other traditional (and smaller) ergonomic tasks at the same time. Only one ergonomist did not talk about resource allocation as a constraint in the project he had been involved in. In the case of the seafood project, he felt that ergonomics had been prioritized in line with the

different engineering areas of expertise. A special circumstance in this project was that the client had agreed to allocate extra money for an ergonomist to participate in the design job.

#### *4.2 Payment for ergonomic services*

A dilemma revolved around whether to include the ergonomic services in the overall price of projects or to sell it as an extra service. Including ergonomic services in the overall price of projects was not seen as a suitable strategy. If the overall price of projects was increased, it would be harder to compete on price. Both ergonomists and engineering designers reported that the best option would be to sell ergonomics as an extra service; however, this solution was not without challenges. In Denmark, all new buildings and production facilities must comply with existing OHS legislation. This rule constituted a dilemma in the consultancy firm, because all design tasks the consultancy firm engaged in had to live up to OHS legislation – with or without the involvement of ergonomists. Both ergonomists and engineering designers reported that they found it difficult to meet this challenge.

Business unit manager: “We cannot just add it [OHS] to the bill, because we are already saying we are doing that, just without the involvement of ergonomists.”

Ergonomic manager: “Some clients will say: ‘Well, you have to live up to the OHS legislation in the services you deliver. What do we get extra?’”

#### *4.3 The value of ergonomic services*

The integration of ergonomic services was constrained by the engineering designers’ doubt about the cost benefits of the ergonomic contributions and the ergonomists’ reluctance to go into cost benefit discussions. Typically, the engineering designers were positive about the potentials of involving ergonomists in design, due to the possibility to improve the quality of projects. At the same time, however, they were unsure about the cost benefits of the ergonomists’ contributions in relation to *how* and to *what extent* the ergonomists should be

involved. Therefore, they would like the ergonomists to present cost benefit arguments. Many also found that involving ergonomists implied increased complexity of the design projects.

PM: "I don't think that there is any area where it [the involvement of ergonomists] hasn't worked well. But I sometimes think that we spend too much money on it."

ED: "All I am saying is that maybe one should look at what is gained on the bottom line for the money spent on ergonomics. Would it have been okay with less? ... It costs extra to say, 'No, we have to move this.' Does it really create better working conditions?"

PM: "Ergonomists should be much more specific on why they are worth the price. They are a little scared of money."

From the perspective of the ergonomists, the benefits of integrating ergonomics into designs seemed more straightforward. The ergonomists believed that their services could contribute to better workplaces for the end users. However, they were reluctant to go into the financial aspects of integrating ergonomics in design. Several ergonomists acknowledged that the ergonomists in general are not good enough at accounting for the cost benefits of integrating ergonomic services into design projects.

Ergonomist: "We think that we can contribute with something that can improve the buildings for the people who are going to use them. For years, we have been trying to make our colleagues understand this. ... The main reason they haven't is that we [the ergonomists] are not communicating properly. We are not accurate enough when it comes to addressing the value of integrating ergonomics in design. ... We are still not good enough at arguing for what we can, how to include it, and the difference it makes. Is it a good investment – and why?"

#### *4.4 The role of the client*

The ergonomic ambitions of the client and their willingness to pay for ergonomic services constituted a barrier *and* a facilitator for involving ergonomics in design tasks. Participants

reported that clients determined whether or not resources were allocated for ergonomics. For ergonomics to be involved in projects, it was necessary that ergonomics was addressed either in the sales material provided by the client, during the initial dialogues with the client, or once the project had been initiated. The general position among the engineering designers was that it was up to the individual client whether or not to involve an ergonomist in the design projects.

PM: "It is up to the client whether he wants to include it [ergonomics] or not."

Many participants, both ergonomists and engineering designers, found it problematic that the engineering designers had the main contact with the client. One possible pitfall was that the engineering designer would forget to include ergonomic aspects in the sales process. Another pitfall was if the engineering designers did not have the competencies to sell the ergonomic services.

PM: "The overall challenge is to sell the ergonomic services and to remember to include ergonomics in sales."

PM: "It is important that the person who is in contact with the client can make clear to the client what he gets and what he doesn't get. Right now, the building people [the engineering designers] don't know much about ergonomics, and they are the ones handling sales and the dialogues with the client."

#### *4.5 Coping and forming strategies to overcome resource constraints*

The ergonomists' efforts to get resources for engaging in design activities were in practice largely dependent on the individual ergonomist. Strategic or planned efforts turned out to have minor effect, as they were not formally evaluated or followed through. A formal staffing procedure in the engineering consultancy was introduced to ensure cross-disciplinary work. According to the ergonomist involved in the staffing procedure, however, the initiative only had minor effect and did not solve the experienced resource constraints. In the ergonomic

department, a growth plan for “integration of ergonomic knowledge in design” was developed and approved by the CEO. Subsequently, however, the ergonomists did not manage to ‘sell’ the plan to prominent design actors, and the initiatives to implement the plan faded out. Finally, we noted that among the ergonomists, there was not much talk about how to make the ergonomic services in design more effective, for instance by introducing uniform ways of addressing ergonomics in design.

In the following, we account for how the individual ergonomist speculated about and developed strategies for acquiring resources both to enter design and become involved in projects.

#### *4.5.1 Coping and forming strategies to enter design*

We found that the majority of the ergonomists developed ideas about how to gain access to design projects. A couple of the ergonomists talked about how to promote their services to the engineering designers.

Ergonomist: “We shouldn’t tell them [the engineering designers] what we can do. We should listen to what their tasks are and *then* describe how we can improve their project – also profit-wise.”

Other ideas were related to the challenges of getting paid for ergonomic services. One ergonomist suggested promoting ergonomic sale by focusing on services that the engineering designers were not saying they were providing already – for example, the ergonomist’s ability to facilitate processes. Another idea revolved around introducing different ‘ergonomic packages’, which could be included in sales, for instance, in the form of an idea catalogue with a guiding price list. This was also suggested by engineering designers. Several of the ergonomists also argued that gaining access to the client would enhance the possibilities of being involved in design projects:

Ergonomist: "It is the client who decides which music should be played."

One often proposed strategy was to team up with the engineering designers at the sales stage. This strategy was used successfully in the seafood case, where a leading manager in the ergonomic department and the PM had teamed up in the sales stage and managed to sell ergonomics as an extra service in the design work – at additional cost to the client. One engineering designer reported however that teaming up in sales was not always successful:

ED "There are some of our customers who view consultants as a burden on their budget. They have to use us, but it is a necessary evil. And everything that raises the cost will make them put their foot down. ... I cooperate a little with ergonomists on sales for a number of clients who I am in charge of. ... but it's very hard to get in, because most of them have the attitude that 'ergonomics is something we can take care of ourselves'."

#### *4.5.2 Coping and forming strategies once involved in projects*

Once involved in a design project, individual ergonomists developed different strategies for obtaining resources during the course of a project. Most ergonomists sought resources through discussion with projects PMs. Some carefully considered how to engage in resource-related discussions, while others were less structured in their approach. One structured approach was to make internal contracts with the PM, where agreed ergonomic activities were listed along with deadlines and time estimations. The ergonomist who used this strategy recommended it as a means to engage professionally in resource discussions. When asked to carry out additional tasks, he would refer to the internal contract and argue that more hours were needed to complete the additional task.

In the hospital case, we found that the leading ergonomist sought to obtain resources for ergonomic services by aiming directly at the "ergonomic ambitions of the client". He had great success in going around the already established contact between the engineering designers and

the client, and managed to create an alliance with an ergonomist working for the client organization. Together, they formed an OHS policy for the entire design project, which they made sure to get approved at all management levels. This was described as a breakthrough, as it made the project management team take a stand with regard to the project's ergonomic ambitions. On this basis, the ergonomist from the engineering consultancy managed to negotiate an agreement where 0.15% of the total budget was earmarked for involving ergonomists in design activities. This made a huge difference in the project:

Ergonomist: "We don't have to explain every time and ask for hours. We are paying ourselves. This makes a huge difference. Everybody has opened up and used us."

The approved OHS policy was deliberately communicated broadly, so that everybody in both the client and project organizations knew of the OHS ambitions. As a result, the OHS policy functioned successfully as a safeguard against cutbacks during the course of the design project.

## **5. Discussion**

We found that resource constraints primarily emerged at 'the internal marketplace' inside the engineering consultancy firm, as ergonomists and engineering designers speculated, discussed and reflected upon their experiences regarding how to integrate ergonomic services into the engineering design processes. A main focus in the engineering consultancy was to maximize the revenue of the individual design projects. This focus, in the absence of a separate 'ergonomics budget', constituted a barrier for the integration, as ergonomics was seen 'as another mouth to feed'. We also found that the engineering designers requested cost benefit arguments for ergonomic services, but that the ergonomists were reluctant to go into this discussion. The client's ergonomic ambitions and willingness to pay for ergonomic services were critical for the possibilities for integrating ergonomics in design.



### 5.1 Sub-optimization of costs

The design tasks were completed in a client-consultant setting, and in the engineering consultancy we identified a strong focus among the engineering designers on minimizing design costs in order to maximize project revenues. According to Béguin [21] the division between client and consultant can be problematic, especially if the boundaries between the parties are too impervious. Based on the present study, we suggest that with regard to resource allocation and integrating ergonomics in design, the boundaries do appear to be rather problematic. The ‘construction’ of split responsibility between consultancy and client in the design and operation phases respectively leads to a sub-optimization of resources. In the engineering consultancy, this manifests itself in the constant focus on minimizing design costs, which overshadows the focus on optimizing operational costs in the client organization.

The sub-optimization of resources in design conflicts with the rationale behind integrating ergonomics in design: The benefit of involving ergonomists in design should be seen in a joint consultancy and client organization perspective, because the benefits can be largely linked to increased system performance in the client organization [1,2,3]. It has previously been found that intra-organizational boundaries can be problematic when attempting to integrate ergonomics in design, for instance in manufacturing companies [30]. The challenge for ergonomists engaged in design in a client-consultant setting, however, appears to be to promote ergonomics in a setting where the engineering designers are separated both inter-organizationally *and* financially from the potential savings of involving ergonomics in design. Engineering consultancies that wish to support integration can consider including ergonomics in the organizations’ strategic goals [2,31] as well as *implementing* the strategy, for instance by incorporating ‘the selling of ergonomic services’ as a goal in internal performance measurement systems. We noted that involving ergonomists was regarded more as a project expense rather than an opportunity to increase overall revenue in the consultancy.

### 5.2 The key role of engineering designers

The engineering designers were in charge of the design processes, which gave them a key role in relation to integrating ergonomics in design. Their doubt regarding the cost benefits of integrating ergonomic services in design seems to have contributed to shaping the identified resource constraints. A link between key stakeholders perceiving ergonomics to have a low value and scarce resources for ergonomic initiatives has previously been established in the literature [6,8,32]. Dul et al. [33] also argue that the integration of ergonomics in design depends on a demand for ergonomics by design actors. We identified that all the engineering designers were positive about the potential of integrating ergonomics in design in the form of increased quality. However, the ergonomists only experienced to a minor degree a 'pull' from the engineering designers. Following the argumentation by Dul et al. [33], the "positive expectations" for added value from integrating ergonomics in design obviously did not match the engineering designers' concerns regarding increased project complexity and increased design costs. It appears that among the engineering designers, OHS is mostly seen as an OHS issue rather than a performance enhancing activity. This aspect has recently been addressed by Theberge and Neumann [34].

In the engineering designers' key role as project managers, they had the main contact with clients. We hypothesize that this creates challenges for ergonomics being integrated into engineering design practice, because many engineering designers do not have the knowledge or competencies to 'sell' ergonomics. One way to promote the ergonomic agenda is to provide ergonomic training for the engineering designers in order to prime them to be able to address the ergonomic agenda in their dialogue with clients.

### *5.3 Ergonomists lack cost benefit argumentation*

The ergonomists were reluctant to go into the cost benefit argumentation and found it hard to argue for the value of ergonomics. One explanation for this finding is that being part of a commercial market was new to the ergonomists, so they needed to learn to how to act in an engineering consultancy's business-driven design setting. Haslegrave and Holmes [22] argue

that design is a commercial discipline where cost benefit argumentation is an incorporated part of the practice. Hence, if ergonomists are not able to meet engineering designers' requests for cost benefit arguments, this contributes to reinforcing resource constraints. As previously noted, difficulties in arguing for the cost benefits of ergonomics have often been described in the HF literature. According to Tompa et al. [35], the lack of economic evaluations of ergonomic initiatives can partly be ascribed to the ergonomists' lacking ability to conduct these evaluations. Recently, more evaluation models have been developed, and several evaluations showing the cost savings of ergonomic initiatives have been published [3,18,35,36,37]. Despite the identified difficulties in expressing the cost benefits of ergonomic services, we support previous publications [10,33], which argue that ergonomists need to be able to enter into dialogue about the cost benefits of ergonomics in order to be able to demonstrate the value of ergonomic services and thus *sell* ergonomics to main stakeholders. In relation to the identified resource constraints, however, it is a challenge that economic evaluations and cost benefit analyses can be quite time consuming to conduct [35]. In a business-driven setting, it might be difficult to obtain resources to conduct such evaluations. An alternative strategy for ergonomists is to rhetorically link the ergonomic initiatives to system performance goals by using 'goal hooking'. The underlying idea here is that it might be easier to implement ergonomic initiatives, if system designers can see that it contributes to fulfilling their own goals [6,31]. It might also diminish the need for cost benefit arguments, if engineering designers can see that ergonomic services contribute to fulfilling their own goals.

#### *5.4 Competencies to overcome resource constraints*

Organizational and strategic initiatives played only a minor role in ergonomists' coping strategies in relation to the identified resource constraints, as these strategies were either not implemented in practice or not able to overcome the identified constraints. Hence, at the operational level in the engineering consultancy, overcoming resource constraints depended heavily on the individual ergonomist's ability to act in the setup of engineering design practice.

One of the identified strategies among the ergonomists for working around the resource constraints was to *identify* and *pursue* the ergonomic ambitions of the individual client. Especially the leading ergonomist in the hospital case was exemplary in his ability to strategize and reflect about how to work around the resource constraints he experienced. Drawing on Broberg and Hermund's [38] concept of the "political reflective navigator", we argue that this ergonomist was able to fulfill this role. He was "skilled in political and reflective processes" [38] and succeeded in building alliances that helped him to push the ergonomic agenda. Neumann et al. [30] distinguish between navigating as an internal or external navigator. In the hospital case, an alliance was formed between an internal and external 'ergonomic navigator'. This alliance proved successful in relation to working around the problematic boundaries of the client-consultant setup and overcoming the constraints related to obtaining resources for ergonomic counseling in projects. A prerequisite for using this strategy, however, is that it is possible to identify an ergonomic navigator in the client organization, and that this navigator has the skills to establish a power base among decision makers.

Finally, we also noted that among the ergonomists, there was not much talk about how to make the provision of ergonomic services in design more effective by for instance introducing uniform ways of addressing ergonomics in design. There was some talk about introducing 'ergonomic packages' to support engineering during sales, but this had not been implemented at the time of the study.

### *5.5 Implications for practitioners*

Based on the present study, we argue that possibilities for integrating ergonomic knowledge into engineering design processes in a business-driven setting largely depend on the ergonomic ambitions of the clients as well as the individual ergonomist's ability to act in relation to design. We hypothesize that engineering consultancies and ergonomists wishing to promote the integration of ergonomic services in design processes can:

- Pursue the ergonomic ambitions of clients by 1) teaming up engineering designers and ergonomists in sales, and 2) identifying and creating alliances with stakeholders in client organizations that can promote an ergonomic agenda inside client organizations.
- Provide ergonomic training for engineering designers in order to enable them to address ergonomic issues in dialogues with clients.
- Provide engineering design training for ergonomists to enhance their understanding of and ability to act in design processes.
- Start a standardization process with an aim of developing ‘standardized ergonomic design services’ that can be linked to engineering design processes, which may reduce the cost of integrating ergonomics in design. A related recommendation is to create an idea catalogue featuring the ‘standardized ergonomic design services’, which includes cost benefit estimates. Such a tool should aim to support engineering designers during the sales stage and support ergonomists in dialogue with both internal and external stakeholders.
- Consider including ergonomics in the engineering consultancy’s strategic goals and taking initiatives towards implementing the strategy, for instance by including ‘selling ergonomic services’ as a goal in performance measurement systems.

## *5.6 Limitations*

The study has some limitations. Since the findings in this paper are based on a single case study, it can be argued that they cannot be generalized to a larger population [23]. Furthermore, the overall subject of the conducted interviews was “integration of ergonomics into engineering design”, which can be seen as carrying a specific agenda, namely that ergonomics should be involved in design projects. The interviewer was aware of this. As part of the study, it was interesting to learn about different viewpoints as to whether or not ergonomic services should be included in design processes and the challenges this would present. It turned out, however, that all the interviewed engineering designers appeared to be positive about the

potential benefits of integrating ergonomics in design processes. This could be because they considered the interviewer (the first author) to be ‘an ergonomist’. Such an effect is known as ‘social-desirability bias’ [39], which refers to the possibility of respondents answering in a way that makes them look better in the eyes of the interviewer.

In further studies, it could be interesting to test whether the finding and conclusions of this paper apply in other similar but also different settings.

## **6. Conclusion**

In this paper, we set out to explore the shaping of resource constraints when integrating ergonomic knowledge into the engineering design processes in an engineering consultancy. Based on our findings, we hypothesize that the resource constraints were shaped as a consequence of a sub-optimization of costs in design jobs undertaken in a client-consultant setting, in that potential savings in connection with ergonomic initiatives should be evaluated on the basis of the ‘life cycle’ of the designed workplaces. Some organizational initiatives were established to overcome the resource constraints, but they seemed only to have a minor effect. In practice, the ability to overcome the resource constraints depended largely on the individual ergonomist’s ability to act in an engineering design setting. The most successful strategy to overcome the resource constraints proved to be to pursue the ergonomic ambitions of the individual clients, either by teaming up with engineering designers during the sales stage or by creating an alliance with an ‘ergonomic navigator’ in the client organization.

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Table 1

Yin's four basic types of designs for case studies (adapted from Yin, 2009)

Table 2

Characteristics of the design cases (PM= Project Manager, ED= Engineering Designer)

Table 1

	<b>Single-case design</b>	<b>Multiple-case designs</b>
Holistic (single-unit analysis)	Type 1	Type 3
	Single-case (holistic) design	Multiple-case (holistic) design
Embedded (multiple units of analysis)	Type 2	Type 4
	Single-case (embedded) design	Multiple-case (embedded) design

Table 2

<b>Case characteristics</b>	<b>Sterile processing plant</b>	<b>Seafood company</b>	<b>Hospital project</b>
The design project	Detailed project proposal incl. layout and logistics.	Conceptual design plan comprising a screening of the current situation in the seafood company and recommendations for future development, incl. conceptual layout plan for one factory.	A new building project involving consultancy in all design phases.
Motivation for integrating ergonomics	The ergonomic department had been consulting at the hospital for years. The hospital and the PM thought it would be a good idea to involve an ergonomist.	The PM and a leading manager in the ergonomic department teamed up in the sales stage and sold ergonomics into the project contract.	Ergonomics was addressed in the sales material for the architecture competition. This was an opening to involve ergonomists in the project.
Participants	- PM: engineering designer - EDs with different backgrounds - An ergonomist	- PM: engineering designer - EDs with different backgrounds - An ergonomist	A consortium working together and consisting of - Two architectural firms - Three engineering consultancies (incl. ergonomists) - Three sub-consultancies
Involvement of ergonomists	An ergonomist involved in part of the design process through: - A visit to the future locations - Layout meetings - A project meeting	An ergonomist involved in the project through: - Trips to the client's factories - a meeting with providers - Various project meetings	Several ergonomists were engaged throughout the design processes through: - More than 400 'user meeting' - Responsibility for design lab and full scale mock ups - Various project meetings - Continuous dialogues
Ergonomic deliverables	- An ergonomic guideline document to feed into the further design process - Recommendations included in the final layout sketch	- An individual ergonomic assessment report for each of the four factories - Inputs such as cost estimates and ergonomic assessments for the structural analysis report - Minor inputs for the master plan	- A room-specific database - A health and safety policy - An ergonomic requirement list, which due to resistance changed name to a recommendation list - An agreement that engineering designers and architects should seek ergonomic support if recommendations were hard to meet
Data collection	- Retrospectively - Interviews N=10, - Document study - To a minor degree observation	- Ongoing project - Interviews N=3 - Observation - Document study	- Ongoing project - Interviews N=6 - To a minor degree observation - To a minor degree document study
Data collection period	- Oct. 2009 to March 2010	- Nov. 2009 to Jan. 2010	- Oct. 2009 and - May 2012 to July 2012